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COMPARISON OF PRE, POST AND SYMMETRICAL DISPERSION COMPENSATION SCHEME WITH 10 GB/S NRZ LINK FOR SCM SYSTEM

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Abstract - In this paper, the implementation of subcarrier multiplexing technique is developed and investigated with pre-, post- and symmetrical-dispersion compensation methods for 10 Gb/s non-return to zero (NRZ) links using standard and dispersion compensated fibers through computer simulations to optimize high data rate optical transmission. Mathematical analysis is done to evaluate performance in term of bit error rate. Simulation is done using Optisys Software version 10.0. Motivation to this research is to compare all three compensation methods and it is found that the symmetrical compensation method is superior to pre- and post-compensation methods. On comparing pre- and post-compensation methods, it is found that the later is superior to the former. A 10-Gb/s SCM test bed has been set up in which 4 * 2.5 Gb/s data streams are combined into one wavelength that occupies a 20-GHz optical bandwidth. Thus by using these comparisions one can get a promising system to the symmetric high capacity access network with high spectral efficiency, cost effective, good flexibility.

Keywords— *Compensating device, Electrical drivers, MZM (Mach Zender Modulator), Bit Error Rate, Quality Factor, SCM(Subcarrier multiplexing), Optisys Software version 10.0.*

I. INTRODUCTION

There are lots of technologies in optical network with which lots of work has been done previously like Time Division Multiplexing (TDM), Wavelength Division Multiplexing (WDM) by which use of the optical Bandwidth provided by the optical Fibers become more efficient. SCM follows a different approach compared to WDM. In WDM a Tera hertz optical carrier is modulated with a baseband signal of typically hundred of Mbit/s. In an SCMA infrastructure, the baseband data is first modulated on a GHz wide subcarrier that is subsequently modulated in the THz optical carrier. This way each signal occupies a different portion of the optical spectrum surrounding the centre frequency of the optical carrier. At the receiving side, as normally happens in a commercial radio service, the receiver is tuned to the correct subcarrier frequency, filtering out the other subcarriers.

Because of its simple and low-cost implementation, high-speed optical data transmission using SCM technology attracted the attention of many researchers. The most significant advantage of SCM in optical communications is its ability to place different optical carriers together closely. This is because microwave and RF devices are much more mature than optical devices: the stability of a microwave oscillator is much better than an optical oscillator (laser diode) and the frequency selectivity of a microwave filter is much better than an optical filter. Therefore, the efficiency of bandwidth utilization of SCM is expected to be much better than conventional optical WDM. SCM is existing technology that has been used in radio, cable-TV and satellite at much lower data rates. In all these applications the use of SCM technology is in CATV technology [1, 2].

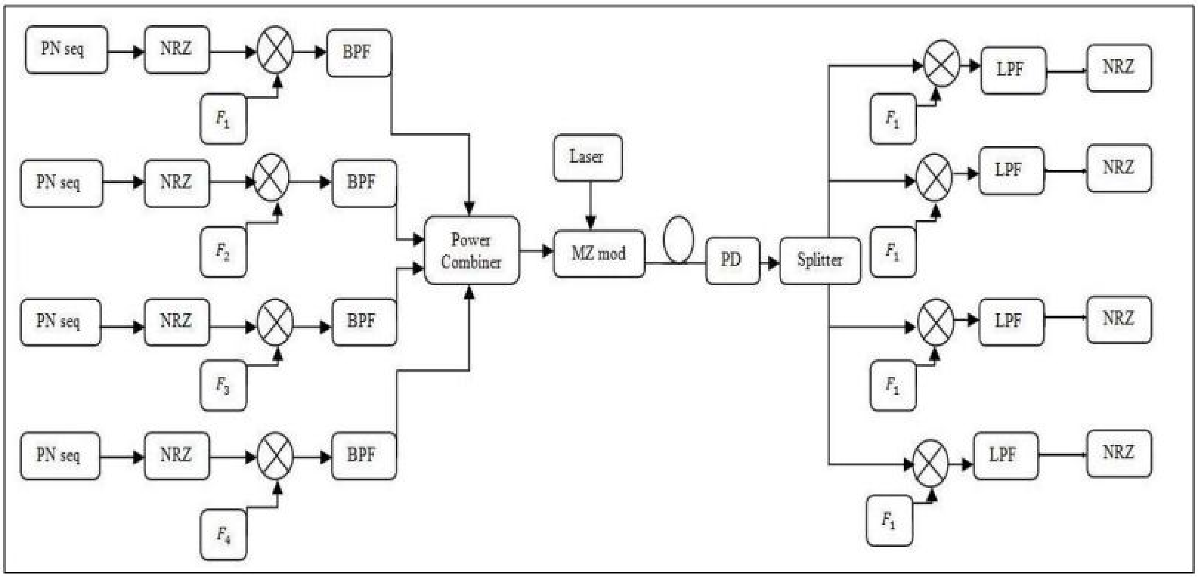
It is most promising method to use dispersion compensating fiber (DCF) efficiently to upgrade installed link made of standard single mode fiber (SMF) [3].These type of passive and devices are superior for SCM systems, commercially available, easy to install and cascadable in networks, indicating that at present the DCF technique can effectively compete with any other dispersion management approach. Whenever SMF is used in any research for high bit rate transmission with low loss but dispersion is an important impairment that degrades overall system performance. As length of fiber increased or bit rate increased or number of channels increased, the dispersion-induced broadening of short pulses propagating in the fiber causes crosstalk between the adjacent time slots, leading to errors when the communication distance increases beyond the dispersion length of the fiber[4]. To combat dispersion and nonlinearities, each SCM channel can separately be pre-compensated, post-compensated or dual-compensated schemes. The use of erbium-doped amplifiers (EDFAs) operating in the 1.55 lm region has increased the link distance as limited by fiber loss in optical communication systems and increases the gain of signals. However, these amplifiers induce nonlinear effects.

In this paper we have developed a link of SCM with NRZ (non return to zero) as line coding and Binary Phase Shift Keying (BPSK) modulation for mixing of RF signals of different frequencies with 10 Gb/s high speed digital signals. Here this paper, we compare these three dispersion compensation methods and evaluate the performance characteristics for dispersive optical communication systems. In the literature [5], post-compensation method was discussed calculated BER for all 4 channels. Here, the results of symmetrical compensation method are compared with pre- and post-compensation methods on the basis of important additional features like bit error rate, Q factor. In Section 2, the optical simulated project and parameters are defined. In Section 3 comparison results have been reported for these compensation methods and finally in Section 4, conclusions are drawn.

II. THE SYSTEM CONFIGURATION

Simulation Analysis

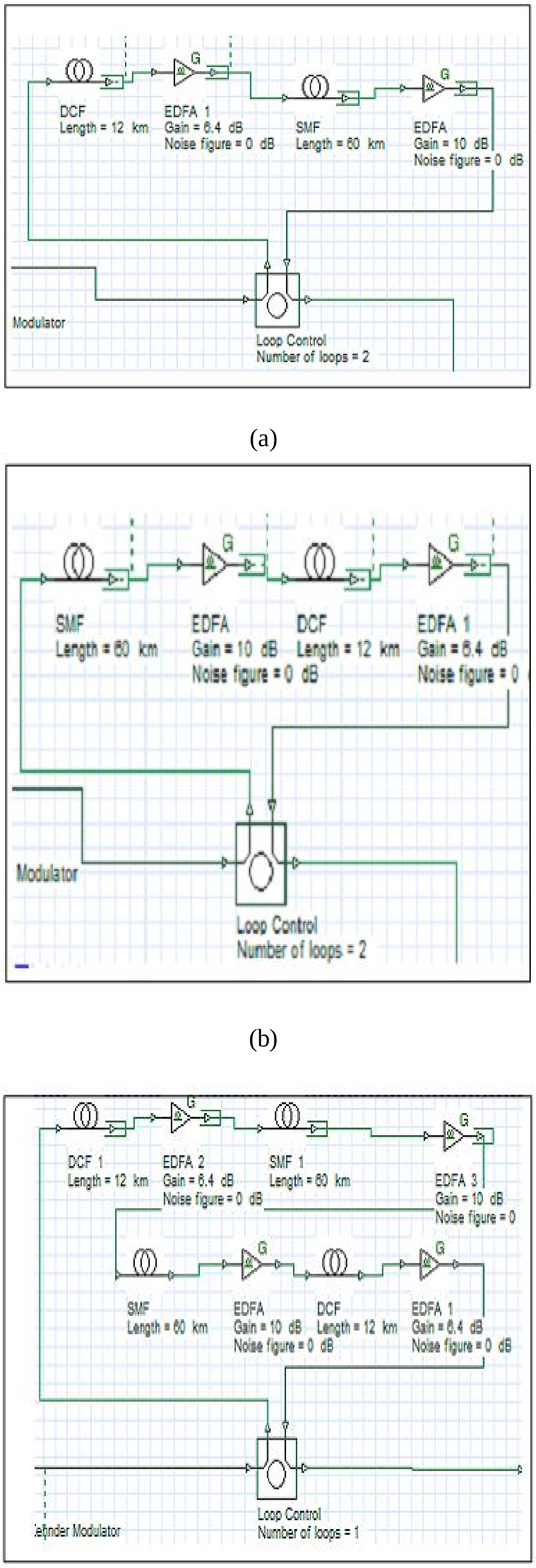
The block diagram of a basic architecture of the subcarrier multiplexing with NRZ code is shown in figure 1. The System is designed by using Optisys ver. 10 which is used in many optical fiber simulations. The bit rate in all four channels is 10 Gb/s. The transmission medium is ITU-T G.652 standard single mode fiber. The attenuation and dispersion were set at 0.25dB/km and 18ps/nm-km, respectively. The performances of the SCM with pre-, post-, pre-post method were characterized by referring BER, eye diagrams and Quality Factor (Q). The basic diagrams for all three schemes are also shown in figure 2.



In generated link transmitter consist of NRZ coder with 10 Gb/s of data, microwave mixer, BPF, combiner and optical modulator (MZM). The receiver consists of photo detector, splitter, microwave mixer, LPF. At the transmitter, data with independent unipolar digital signal is mixed by a different microwave carrier (f_i). The subcarriers are combined and optically modulated using an optical electrical modulator (OEM). Then n modulated code sequences are multiplexed together and transmitted through the optical fiber. Then, the decoded signal is detected by the photo detector. A splitter and an electrical Band Pass Filter (BPF) are used to split the subcarrier multiplexed signals and reject unwanted signals, respectively. In order to recover the original transmitted data, the incoming signal is electrically mixed with a microwave frequency f_i; and filtered using LPF.

Compensation is done by three methods, pre-, post- and symmetrical compensation. In the first method, the optical communication system is pre compensated by the dispersion compensated fiber of negative dispersion against the standard fiber. In the second method, the optical communication system is post compensated by the dispersion compensated fiber of negative dispersion against the standard fiber. In the third method, the optical communication system is symmetrically compensated by two dispersion compensated fibers of negative dispersion against the standard fiber in between. Due to the nonlinear nature of propagation, system performance depends upon power levels [6] and the position of dispersion compensated fibers [7]. Dispersion compensation fibers are specially designed fiber with negative dispersion. To compensate positive dispersion over large length of fiber high value of negative dispersion is used.

Spans made of single mode fibers and dispersion Compensated fibers are good candidates for long distance transmission as their high local dispersion is known to reduce the phase matching giving rise to four waves mixing in SCM system. The simulation setup of all three schemes is created by using software shown in figure 3.



(a)

(b)

(c)

Figure 3: Simulation setup: (a) pre-compensation with 60 km link with 2 spans (b) post-compensation with 60 km link with 2 spans (c) pre-post compensation with 120 km link with single span using single mode and dispersion compensating fibers.

Theoretical Analysis

In the analysis of this SCM system, we see the most important parameter is chirp v in such type of externally modulated system as it indicate the phase of the output signal modulator. Thus MZ modulators (MZM) can be designed to operate completely chirp-free, in most devices there is a small residual chirp arising from an asymmetry in the overlap of the electric fields at each electrode. A dual electrode MZM, which allows access to both electrodes, can be used to achieve a variable chirp parameter. For such a device, the chirp parameter can be related to the relative amplitude and sign of the RF drive signals to each electrode VI and V2 as [8].

$$V_1 = \frac{V_1 + V_2}{V_1 - V_2} \qquad (1)$$

The next parameter is α which is ratio of phase of amplitude modulation an defined as

$$\alpha = \frac{1}{2S} \frac{\left(\frac{d\varphi}{dt}\right)}{\left(\frac{dS}{dt}\right)} \qquad (2)$$

Where α and S are the instantaneous phase and intensity at the output of the modulator. For the MZM, α is a function of the modulator depth and de-bias point, and is related to v as [9]. If the MZM has chirp, then fiber length L [2]:

$$L = \frac{c}{2D\lambda_c f_{rfN}} \left(N - \frac{2}{\pi} \arctan(\alpha) \right) \qquad (3)$$

Equation (3) indicates that the fiber-link distance in externally modulated analog systems can be increased when α is large and negative.

The signal to noise ratio SNR at the output of the PD can be expressed as:

$$SNR = \frac{(R_d P_{sc})^2}{\sigma_n^2 + \sigma_{th}^2} \qquad (4)$$

Here R_d the PD sensitivity, σ_{th}^2 is the variance of receiver thermal noise and σ_n^2 is the PD shot noise variance.

The bit error rate including the effect of OBI can be expressed

$$BER = 0.5 erfc \frac{(R_d P_{frf})}{\sqrt{\sigma_{sh}^2 + \sigma_{th}^2 - \sigma_{obi}^2}} \qquad (5)$$

Where, σ_{obi}^2 the OBI.

Table 1 summarized the typical parameters used in BER and Q factor calculation.

TABLE I
ypical parameters used in the performance

Symbol	Model Parameter	Value
R_b	Data bit rate	10 Gb/s
L_{SMF}	Length of SMF	120 km
L_{DCF}	Length of DCF	24 km
D_{SMF}	Dispersion coefficient	16ps/nm/km
D_{DCF}	Dispersion coefficient	-90ps/nm/km
G_1	Gain of $EDFA_1$	20db
G_2	Gain of $EDFA_2$	12.8db
P	Power/ channel	10dbm
α	Fiber loss	0.2dbm
A_{Eff}	Effective mode area	$80\mu m^2$
Δt	PMD coefficient	0.5ps
I_d	Dark current	10nA
2Γ	Line width	5.0 MHz

III. RESULTS AND DISCUSSION

1. Simulation Result

The Figure 4, 5 and 6 show comparisions between BER of all 4 sub-carriers at different received power. In case of multiple uplink channels, the BER of each channel will be reduced because of the accumulation of OBI noise due to the numerous interferences. It is observed that the bit error rate increases with increase in the received power. For symmetrical compensation, the bit error rate is minimum indicating the best performance. For received power up to 13 dBm, the bit error rate is 10^{-18} that is acceptable but if the power is increased from 10 to 12 dBm, it increases to 10^{-9} which is a perfect BER for high data rate optical transmission. Increasing the received power further will bring the BER higher than the defined acceptable level. For post compensation method, the bit error rate is again 10^{-13} up to 10 dBm powers by increasing the power further to 12 dBm, BER goes to10^{-10} that is good enough, when we go though pre-compensation, at 12 dBm powers BER is 10^{-19}, by increasing power it up to 20 dBm it goes to 10^{-10}. The power requirement to getting an acceptable level of BER in case of pre-compensation is more that is also a demerit. So we can easily get a conclusion that BER increases more rapidly for pre-compensation as compared to post-compensation method thereby indicating that the performance of post-compensation method is better than pre- compensation [10].

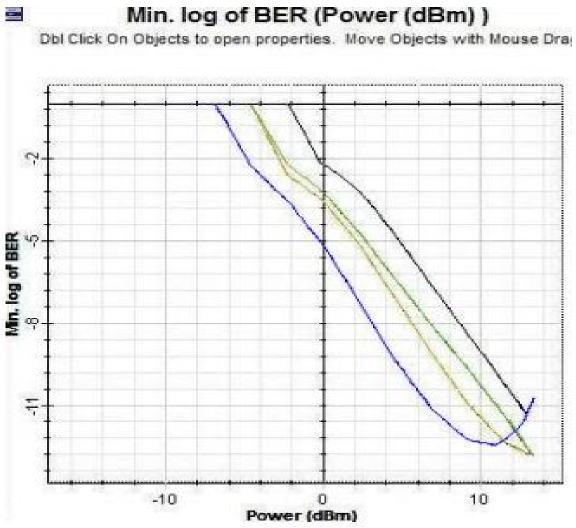


Figure 4: Bit error rate vs. Fixed received power for Post-compensation method BER= 3.30e-13

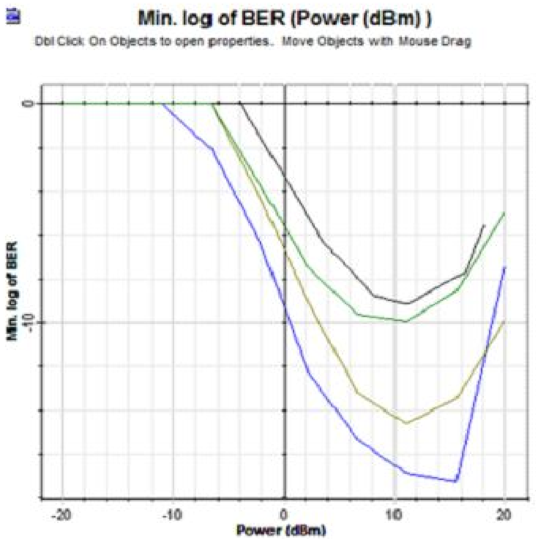


Figure 5: Bit error rate vs. Fixed received power for Pre-compensation method BER= 1.28e-18

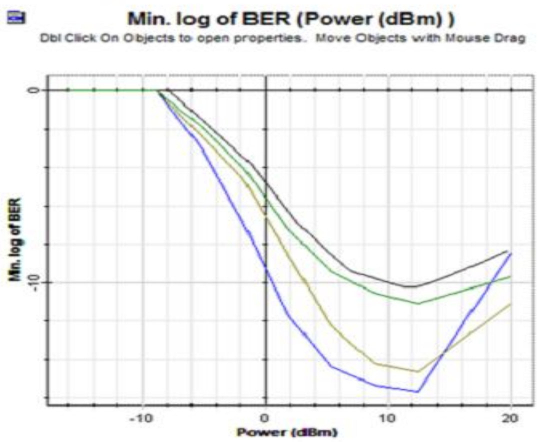


Figure 6: Bit error rate vs. Fixed received power for Pre- Post compensation method BER= 7.930e-12

In Figure 7, 8 and 9 show comparisions between Q factors of all 4 sub- carriers at different received power. As already compared BER of all three schemes Q of all three schemes goes in same manner that for post compensation Q is approximately 7 which is acceptable in range but in case of pre-compensation it goes to 9 that is not in range. In symmetrical- compensation Q factors goes to 7. So we conclude that symmetrical and post-compensation are better than pre- compensation.

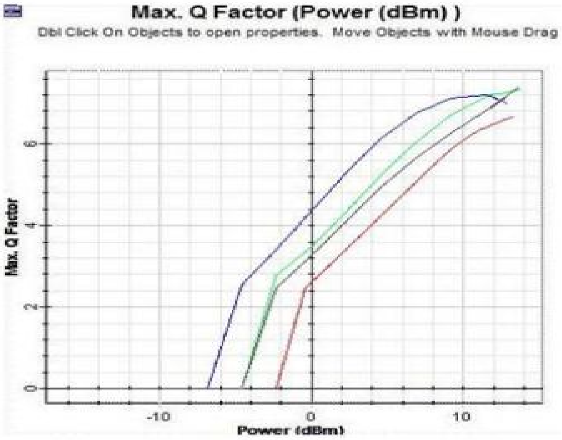


Figure 7: Q factor vs. Fixed received power for Post-compensation method Q=7.2

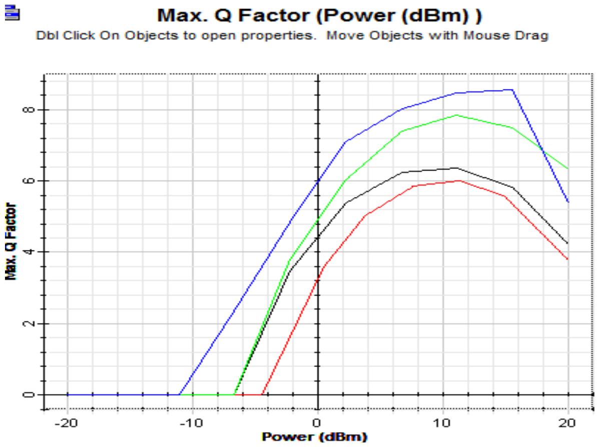


Figure 8: Q factor vs. Fixed received power for Pre-compensation method Q=9.4

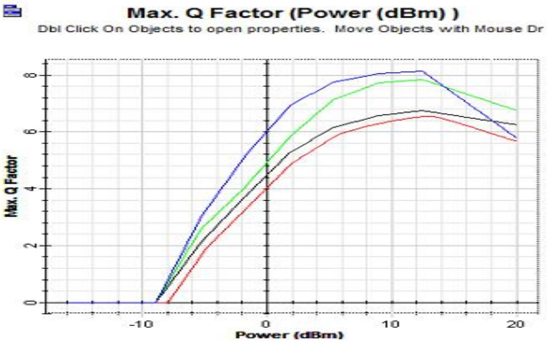


Figure 9: Q factor vs. Fixed received power for Pre- Post compensation method Q= 7

1. CONCLUSIONS

The paper illustrate that comparisions between all three schemes pre-, post-, pre- post compensation for fiber link of 120km. and it describes that in SCM link which method is compatible. The output parameters like BER, Q factor. In simulation results, it is found that as the power increases, the bit error rate increases with non- linearity. The pre-post compensation has the best performance followed by post- and pre-compensation. As this is known that the perfect BER is 10^{-9} and Q factor is 6. So with all result we verify that in symmetrical- compensation BER minimum that is 10^{-9} but in case of both others we conclude BER is more that is not acceptable in case of SCM link with 4 RF sub- carriers. We have suggested using the same schemes for 40 Gb/s. the same technologies can be implemented with SCM/WDM system.

REFERENCES

[1]. R. Phillips and T. E. Darcie, "Lightwave video transmission," in *ptical Fiber Telecommunications*, I. P. Kaminon and T. L. Koch, Eds. New York: Academic, vol. IIIA , 1997.

[2]. P. M. Hill and R. Olshansky, "A 20-channel optical communication using subcarrier multiplexing for the transmission of digital video signals," *J. Lightwave Technol.*, vol. 8, pp. 554-560, Apr. 1990.

[3]. N. Kikuchi, S. Sasaki, and K. Sekine, “10 Gbit/s dispersion compensated transmission over 2245 km conventional fibers in a recirculating loop,” *Electron. Lett.*, vol. 31, no. 5, pp. 375–377, 1995.

[4]. T. L. Koch, R.C. Alferness, J. *Lightwave Technol.* LT-3 (1985) 800.

[5]. Paul D. Sargis etc. 10Gb/s subcarrier multiplexed transmission over 490km of ordinary single mode fiber without dispersion compensation. *IEEE PTL*, Dec, 1997.

[6]. R.M. Jopson, A.H. Gnaules, R.M. Derosier, in: *Proc.OFC’93*, paper pd3,1993.

[7]. A.Yariv, D.Feke, D.M.Pepper, *Opt.Lett.4* (1979) 52.

[8]. A. Djupsjobacka "Residual chirp in integrated optic modulators", *IEEE PhotonTech. Lett.* Vol A, pp. 41-43, Jan 1992.

[9]. Mohammad M. Banat, Mohsen Kavehrad. "Reduction of Optical Beat Interference in SCMlWDMA Networks Using Pseudorandom Phase Modulation." Lightwave Tech. Vol.12, No.IO, October 1994.

[10]. C. Peucheret, N.Hanik, R.Freund, L.Molle, P.Jeppesen, *IEEE Photon.*Technol.Lett.12 (8) (2000) 992.

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